DTU Library

Why doesn't my wind farm produce what I expected? A guide to wind farm performance assessment

Garza, Jorge; Clausen, Niels-Erik; Downey, Raymond; Windolf, Mikkel

Published in:
Proceedings

Publication date:
2011

Document Version
Publisher's PDF, also known as Version of record

Citation (APA):
Garza, J., Clausen, N-E., Downey, R., & Windolf, M. (2011). Why doesn't my wind farm produce what I expected? A guide to wind farm performance assessment. In *Proceedings* European Wind Energy Association (EWEA).

PO. ID
PO.176

Why doesn't my wind farm produce what I expected? A guide to wind farm performance assessment

Jorge Garza[1,2][*], Niels-Erik Clausen[1], Raymond Downey[2] and Mikkel Windolf[2]
[1] Risø DTU, Roskilde, Denmark, [2] DONG Energy, Copenhagen, Denmark
[*] jorca@dongenergy.dk

Abstract

A methodology for wind farm performance assessment has been devised for the case when an on-site met mast is lacking. Over 2 years of SCADA data from an onshore wind farm in continental climate were used for a performance assessment study. This poster focuses only on the results related to wake losses.

Objectives

The paper goes through the method to accurately assess wind conditions at the site when lacking an on-site met mast. The disagreement between estimated and measured production is broken down and the contribution from different factors assessed. The most relevant factors in performance assessment are addressed and sources of bias and uncertainty can be clearly identified given appropriate data.

The main goals of this work are

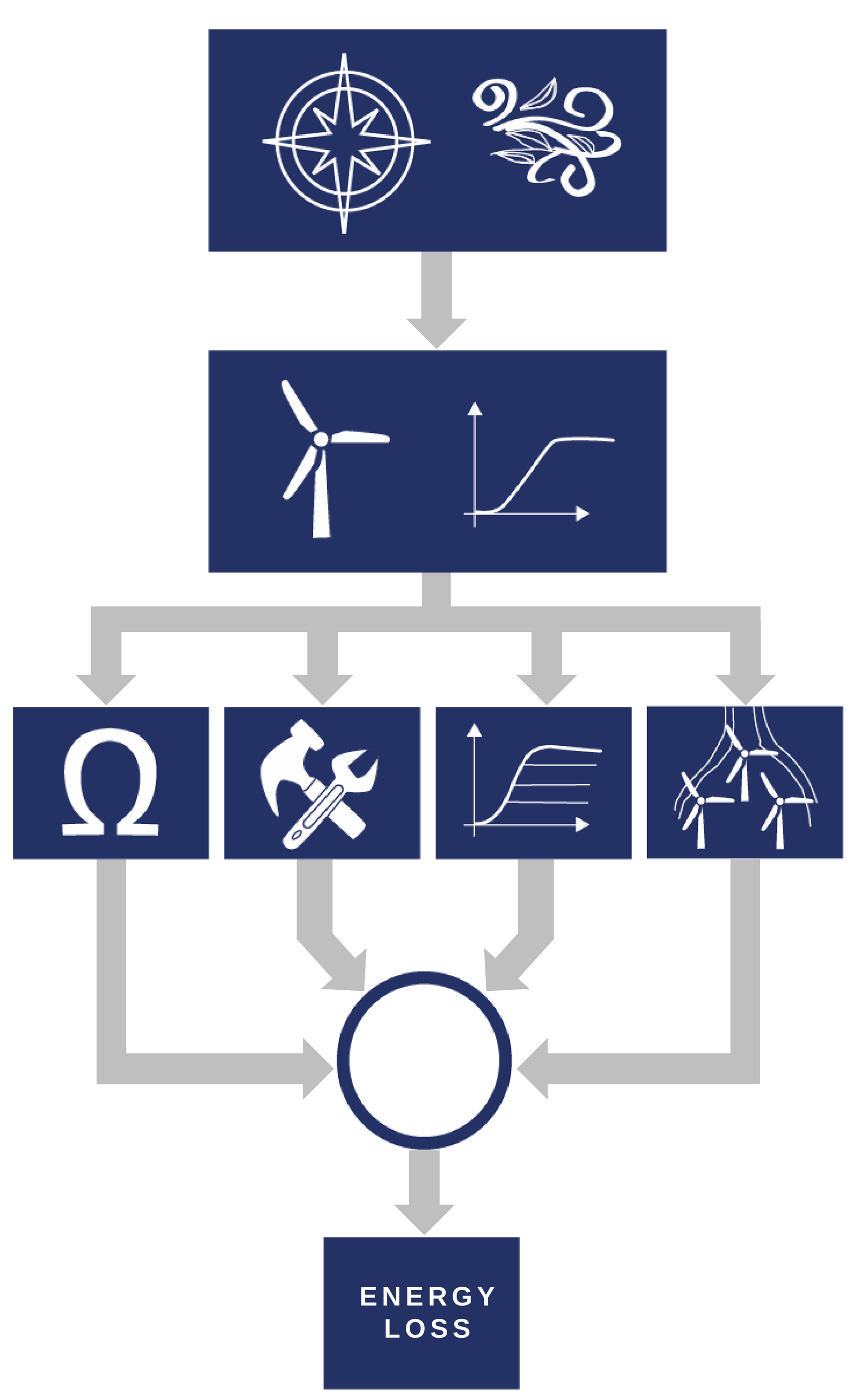
- Revisit estimation methods
- Find sources of bias and uncertainty in production estimates to point improvement measures
- Devise a standard approach to performance assessment of wind farms

After the loss contribution coming from wakes is assessed, further investigation on the topic is made, including comparison with the predicted losses. Only the results related to this further wake analysis are presented here.

Methods

Flowchart of the proposed method

1. Estimate incoming speed for every turbine based on pitch, power and temperature measurements.
2. Estimate free stream wind speed from reconstructed wind speed at undisturbed turbines according to wind direction.
3. Calculate available power from the guaranteed power curve.
4. Calculate overall lost production from available power and wind farm exported power.
5. Deduct various operational losses (electrical, O&M, curtailment).
6. Use fully normal operating data for directional and overall efficiency (wakes).



Two study cases:

Atmospheric stability

Due to their turbulence levels and vertical mixing, different atmospheric stability conditions lead to different wake recovery and wake loss profiles along a transect.

It is of interest to assess the impact of atmospheric stability on onshore wake losses to improve knowledge on how to choose or tune the wake model.

A rudimentary stability classification is implemented by dividing data in winter nights (associated with stable conditions) and spring days (unstable) and comparing turbines in the West-East transect for westerly winds, the prevailing direction.

Forest effect

The presence of forestry modifies terrain roughness and flow displacement height, and it is a complicated factor to assess.

For an area with several forest patches of variable size, it is interesting to assess how their presence affects the nearby turbines. This could be useful for improving forest modeling methods in future estimates.

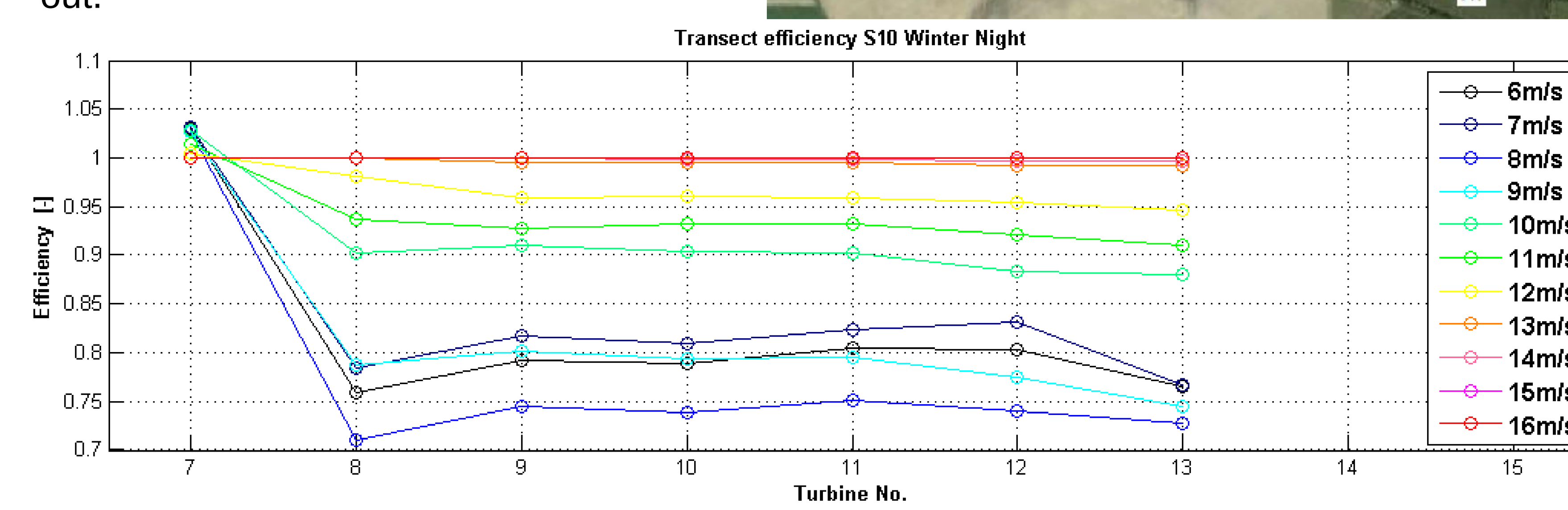
The efficiency curve for a turbine in the free stream is compared to those from turbines that would be in the free stream if the forest was not there.

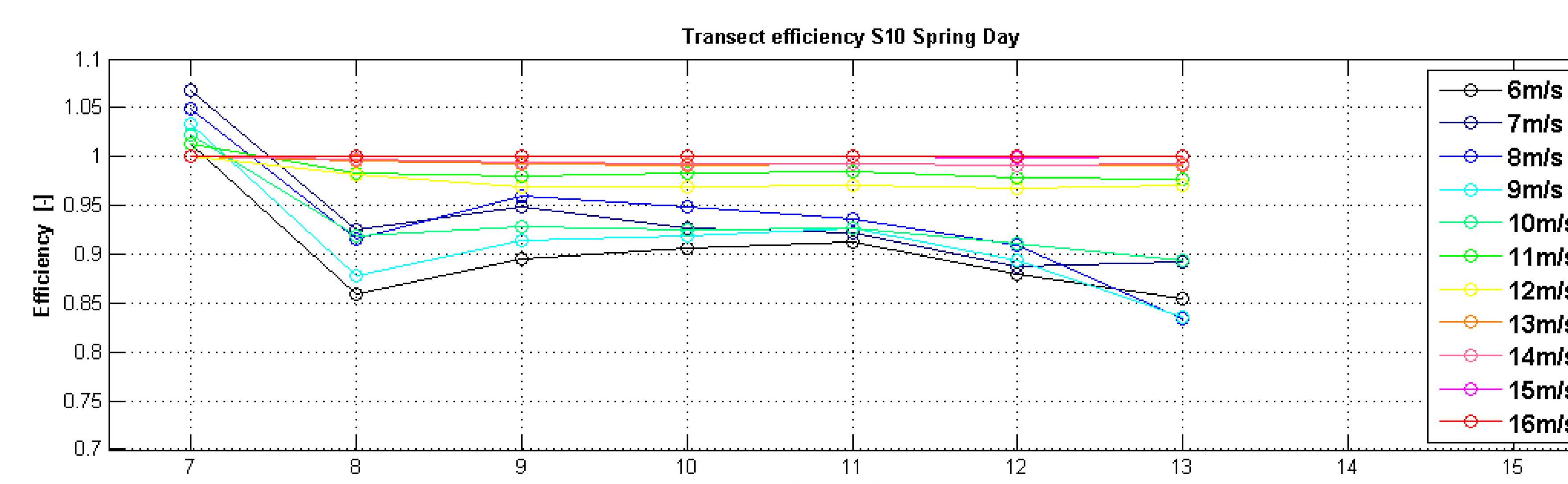
Results

Wake losses

The overall disagreement between the WAsP prediction (v.9, standard N.O. Jensen model) and observed wake losses was 3.5% of the AEP.

Results for the previously described study cases are presented in reference to the map here, where the wind directions and turbines considered are clearly pointed out.





Turbine efficiency profile along the W-E transect for different wind speeds during winter nights (upper) and spring days (bottom).

Stability

Efficiencies are much lower for winter nights (stable, upper plot) than for spring days (unstable, lower plot), with the difference being up to 10%. Turbines reach an efficiency close to 1 at lower speeds during spring.

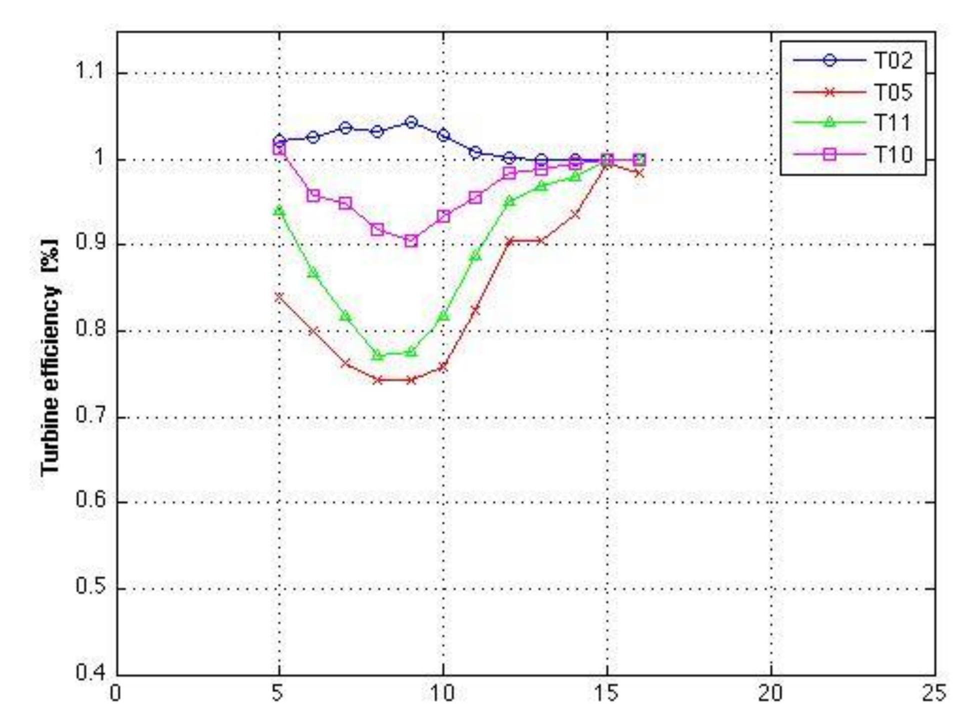
These results agree with the conceptual picture of stability affecting wake development and with previous work on the Horns Rev offshore wind farm [1], which found the same qualitative trend of higher wake losses at stable conditions.

Forests

Turbines near forests had performance hindrance. Different according to forest distance and extent. Turbines not in the immediate vicinity of a forest also had performance hindrance, which indicates forest wake propagation

Findings: performance reduction that can only be attributed to forest wake propagation

Turbine	Distance to forest [m]	Forest fetch [m]
T05	220	420
T11	620	440
T10	900	250



Turbine efficiency per wind speed for turbines at various distances from the forest and winds from the NNE. Colors refer to turbines pointed in the map.

Conclusions

The proposed method can be used to assess wind farm performance in the case where only SCADA data is available, identifying the loss contribution from wind index, availability, electrical losses, curtailment and wakes.

The method has proven to be valuable to assess wake losses, which were found to be underestimated by the standard N.O. Jensen model in WAsP, especially in conditions associated with stable atmospheric stratification. A simple classification of stability was used to assess the impact on wake losses, which was found to be significant.

The effect of nearby forests on wakes was assessed by comparing turbines with similar conditions except for their forest exposure. The effect was seen to be large and affecting turbines moderately far from the forest, in a kind of forest wake propagation.

References

1. Jensen, L. Array efficiency at Horns Rev and the effect of atmospheric stability, *In Proceedings of the 2007 European Wind Energy Conference.*